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## **EXO BIOLOGY -- NEW PROBLEMS AND TASKS IN SCIENTIFIC RESEARCH**

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### Introduction for 1964 by Dr Hermann von Siemens, President

The Bulletin of the Fraunhofer Society, now one year old, has become a familiar institution for the individuals and organizations who are interested in the public-service objectives of our society. We observe with satisfaction that some of the articles or hints printed in our bulletin have been picked up by the press. We will continue to endeavor to maintain active contact with all circles and to expand and intensify this contact. We want to accept our sincere appreciation to all those who have promoted our endeavors, particularly the competent [government] agencies and friendly associations and societies and we would like to express our confidence in fertile cooperation this year likewise.

### Exobiology -- New Problems and Tasks of Natural Science Research

Exobiology deals with the possible presence of life outside the earth, with its phenomena and expressions (particularly metabolism) and with the environmental conditions prevailing on the spot. Even if there were no life on the planets, these probiontic conditions would be of interest. After all, this enables us to find out just exactly what organic compounds can form and can exist, without the action of living things and without their altering influence upon the "original soup" (Urey), for instance, through the "eating" of these substances. But then the field of exobiology also includes the effects of extraterrestrial conditions (for instance, extreme cosmic factors) upon simple earthly organisms. The place for conducting research here would be the extreme layers of the atmosphere of the earth, and, for example, primarily the exosphere (about 400 km and higher) as well as the conditions on the planets and on their moons. In order to conduct this extraterrestrial research, we would then have to become increasingly successful in simulating

such conditions experimentally. In order to engage successfully in the pursuit of exobiology, it will be necessary in a subsequent phase to equip biological probes and to undertake manned space flights. This will bring up additional biological problems involving the creation of biological foundations for guaranteeing these cosmic flights. For instance, the development of suitable circulatory systems which will reduce the ballast in terms of oxygen, water, and food for the crew and which will favorably regenerate the waste products. Through the actual research objective of exobiology -- life in space far away from earth -- we also hope to cast some light into the darkness that still prevails with respect to the very simplest initial forms of life in the very distant times; this will be a new method of exploring this subject. After decades of research it was possible to establish that the fossil documents actually cannot take us back to the original beginnings of the primitive forms of life; then model experiments in the laboratory were undertaken in an effort to find out what the situation might perhaps have been, way back, in the distant beginning. Of the many experiments undertaken along these lines, the best-known is the one by S.L. Miller (1953). A gas mixture consisting of  $\text{CH}_4$ ,  $\text{NH}_3$ ,  $\text{H}_2$  and  $\text{H}_2\text{O}$  was made to circulate for 8 days in an apparatus during electrical discharges. After that Miller found various amino acids in small but entirely weighable quantities, in addition to a mixture of various other organic compounds. According to opinions prevailing until then, the result should have been a mixture of all possible low-molecular C, H, N, O combinations. Amino acids then should have occurred only in infinitely small quantities. The fact that they did occur in quantities that could be weighed indicates that, contrary to the original assumption -- to the effect that we are dealing with accidental events in the formation of these substances -- there exist nevertheless certain definite trends in the C, H, N, O system for [the formation of] certain combinations, in this case, amino acids. Garrison and associates bombarded  $\text{CO}_2$  in a watery solution with alpha particles. Among others, they obtained formic acid and aldehydes (which, long ago, under different conditions, had been used in making sugar). Other ionizing rays likewise act in a similar fashion. It was also possible to produce complicated compounds, even purines, in other words, the building blocks of nucleic acids, in an inorganic fashion. Just exactly in what combinations, in what degree of dependence of mutual influence and timely sequence such simple organic substances are really formed and such processes took place in the very distant past of our earth -- that is something we really have no information on whatever. We can consider these experiments merely as model forms. Here only a much more detailed exploration of the planets and the moons could help create new understanding. We have good reason to assume today that the original atmosphere of the earth, similar to what it still is today on a number of planets, was not oxidative, as it is today, but rather reductive, consisting mostly of  $\text{H}_2$ ,  $\text{NH}_3$ , and  $\text{CH}_4$ . In this kind of gas mixture, S. L. Miller conducted his important experiments. This is why these planets would first of all have to be studied in greater detail in order to determine whether our past assumptions and laboratory research results are not confirmed also from that angle. A rather weak reference point -- indicating that we might be on the right track -- we already have in this respect. Among the stone meteorites there is one type, the carbon-

containing chondrites, in which we find also higher-molecular organic compounds, for instance, paraffins and asphalts. The latter need not necessarily be traced back to living things. Their origin without [living] organisms of course cannot be explained so simply because the conditions which lead to low-molecular organic compounds, for instance, radiation, prevent precisely the formation of high-polymer compounds. But these meteorites at least show us that such higher-molecular organic compounds originate somewhere outside the earth, in a manner which we still do not know anything about, either inorganically or perhaps also through living things. Are there any microorganisms, any DNA, etc., to be found also outside our earth? Bacteria which were reported to have been found in such meteorites could have penetrated even after impact upon the earth. Such microorganisms after all were found meter-deep in fresh granite. Could we now, under the conditions prevailing on other planets, perhaps find even primitive living things, such as they might have existed on the earth in the very distant past and such as they either died out during the transition to the oxidative atmosphere or such as they were eliminated through selection later on?

These questions and scientific realizations are at the same time the working hypotheses for the second phase of the NASA program: the identification and exploration of extraterrestrial life, with the planet Mars being the close-in objective for the immediate future. The Moon, Venus, and Jupiter likewise do not exclude any and all possibilities for the existence of life. But for the time being we will have to confine ourselves to a closer exploration of the physical and chemical environment of the Moon, Venus, and Jupiter. Although we cannot expect that independent life exists on the Moon, there is nevertheless a possibility that sedimented material, which has penetrated from space, might have remained preserved over a long period of time through the absence of an oxidative atmosphere. The research results of the Venus probes might also give us some information as to just exactly what the relatively high surface temperature still allows to exist there. The other planets must necessarily be ruled out because of their distance from and to the sun. Of course, even the planet Mars would be hostile to the existence of living things, judging by the forms of life found on earth. It might be possible to move instrument capsules into the vicinity of Mars in order to expand our current knowledge of the physical and chemical condition of the planet Mars. We are also developing certain types of apparatus which can be landed on the surface of Mars and which could transmit the results to a station on earth. (Such long-range exploration at the same time would offer the advantage of preventing any danger of contamination -- see below!) NASA in particular has developed the Gulliver probe. The operating procedure of the instrument capsule starts from the assumption that certain proteins and DNA are taken on as essential factors for the existence of life. These compounds can be established quite easily with the technically suitably adapted equipment of modern biochemistry. Another possibility involves certain characteristics of the metabolism activity of living substances. The Gulliver probe can collect extraterrestrial material from the surface of planets by means of whip probes. The probe is placed in a nutrient solution containing marked carbon. The presence of living organisms may be revealed through the release

of marked metabolism products (for instance gaseous  $\text{CO}_2$ ). A detector can also release impulses for telemetric measurement. The growth and other data for certain living substances might also be measured by means of various physical and microchemical methods.

Another field of research within exobiology involves the possibility of the adaptation and development of living things in various environments. In a terrestrial laboratory we can also simulate a number of the physical and chemical conditions prevailing in the exosphere. One question that is extremely important here is whether living things in a simple form, micro-organisms, and their spores or virus material can at all exist under the conditions of the exosphere. Likewise we will have to ask ourselves how any biological material, coming from space, would behave upon entry into the earth's atmosphere. This might also give us more information on the panspermia hypothesis of Arrhenius. Because of the danger of the introduction of alien living things into other planets and, vice versa, from there, to earth, we find that the sterilization of space vehicles is today an internationally recognised necessity. Of course, this confronts us with some technically extremely great difficulties. Here we must include the environment of the space ship, respectively, its surface, in these considerations. With respect to the possibly rapid spread and the completely uncertain effects of contamination on our earth, however, we cannot take these problems seriously enough. NASA has already demanded the creation of specialized research installations and facilities, particularly for biochemistry, and quite generally for organic chemistry and biology. Undoubtedly, exobiology does have a task in space research. But this certainly will also enable us to consider a number of general questions -- which so far could not be answered -- at least from a new angle, for instance, the abovementioned problems concerning the prebiotic [sic] development of organic compounds and the appearance of the first forms of life on earth.